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Effect of Nanoparticles on the Human Health and Environment

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ABSTRACT

Nanotechnology has the potential to significantly impact society. Nanoparticles are the tiny particles of nanometre size (millionths of a millimetre). Engineered nanoparticles and nanomaterials offer many potential socio–economic, health and environmental benefits as a result of novel properties and behaviour that materials can exhibit when manufactured at the nanoscale. Materials containing nanoparticles may be of concern for human health and the environment. The present paper reports the effect of nanoparticles on the human health and the environment.

Keywords: Nanoparticles, Human health, Environmental Effects.

INTRODUCTION

Nanotechnology refers to the branch of science and engineering devoted to designing, producing, and using structures, devices, and systems by manipulating atoms and molecules at nanoscale, i.e. having one or more dimensions of the order of 100 nanometres. Nanotechnology and nanoscience are multidisciplinary fields between chemistry, which deals with atoms, molecules and condensed matter physics, which deals with solids of essentially an infinite array of bound atoms or molecules of dimension less than 100 nm.

Natural phenomena and many human industrial and domestic activities, such as cooking, manufacturing or road and air transport release nanoparticles into the atmosphere. Naturally occurring processes that generate nanoparticles in the liquid phase include erosion and chemical disintegration of organic materials (such as plant or microorganism debris) or geological materials (such as clay). Man-made nanoparticles engineered to have the desired size, chemical composition, and surface and charge properties can be produced in the liquid phase mainly through controlled chemical reactions. It is also possible to control conditions at which individual atoms and molecules assemble themselves into the required structure. The formation of nanoparticles in the gas phase in the

atmosphere is in volcanic plumes, and in human activities such as cooking, welding or smelting, and polymer manufacture. Recently, this type of formation of nanoparticles in the gas phase has become an important pathway for the industrial production of nanoparticle powders of metals, oxides, semiconductors, polymers and various forms of carbon, which may be in the form of spheres, wires, needles, tubes, or other shapes.

In rural areas, nanoparticles are the product of chemical reactions involving compounds emitted by living organisms or by human activities such as wood burning. Motor vehicle emissions are the most significant source of nanoparticles in urban areas. The primary sources of nanoparticles are diesel engines or cars with defective or cold catalytic converters. Today, nanoparticles generated by the combustion of fossil fuels constitute the most important source of human-induced nanoparticles.

EFFECTS OF NANOPARTICLES ON HUMAN HEALTH AND ENVIRONMENT

Inhalation is the primary route of human exposure to nanoparticles. The different compartments of the human respiratory tract (nose, larynx, airways and lungs) all act as a filter for nanoparticles. The smaller the particle, its chance to reach the lung is more likely. Inhaled matter can be deposited throughout the human respiratory tract, and an important fraction of inhaled nanoparticles deposit in the lungs. Nanoparticles can potentially move from the lungs to other organs such as the brain, the liver, the spleen and possibly the foetus in pregnant women. Data on these pathways is extremely limited but the actual number of particles that move from one organ to another can be considerable, depending on exposure time. Even within the nanoscale, size is important and small nanoparticles have been shown to be more able to reach secondary organs than larger ones. Another potential route of inhaled nanoparticles within the body is the olfactory nerve; nanoparticles may cross the mucous membrane inside the nose and then reach the brain through the olfactory nerve. The effects of inhaled nanoparticles in the body may include lung inflammation and heart problems. Studies in humans show that breathing in diesel soot causes a general inflammatory response and alters the system that regulates the involuntary functions in the cardiovascular system, such as control of heart rate.

The characteristics of nanoparticles that are relevant for health effects are:

- **Size** – In addition to being able to cross cell membranes, reach the blood and various organs because of their very small size, nanoparticles of any material have a much greater surface to volume ratio (i.e. the surface area compared to the volume) than larger particles of that same material. Therefore, relatively more molecules of the chemical are present on the surface. This may be one of the reasons why nanoparticles are generally more toxic than larger particles of the same composition.
- **Chemical composition and surface characteristics**– The toxicity of nanoparticles depends on their chemical composition, but also on the composition of any chemicals adsorbed

onto their surfaces. However, the surfaces of nanoparticles can be modified to make them less harmful to health.

- **Shape**–Although there is little definitive evidence, the health effects of nanoparticles are likely to depend also on their shape. A significant example is nanotubes, which may be of a few nanometres in diameter but with a length that could be several micrometres. A recent study showed a high toxicity of carbon nanotubes which seemed to produce harmful effects by an entirely new mechanism, different from the normal model of toxic dusts[1].

Engineered nanoparticles are likely to enter the environment either during the manufacture of nanomaterials or through the use and disposal of such products containing nanoparticles, including personal care products such as cosmetics and sunscreens. Currently, very little is known about the behaviour of these particles in the environment.

The present paper reports a review on the effect of the nanoparticles on the human health and the environments. Engineered nanoparticles are normally in the thin film or the powder form causing respiratory problems. As the particles synthesized by us are in powder form and of very small size, they caused the inflammation in the respiratory track resulting in the congestion in the chest and breathing problem. If the exposure time of human interaction with the nanoparticles is more, the inhaled nanoparticles can reach the blood and may reach other target sites such as the liver, heart or blood cells. Key factors in the interaction with living structures include nanoparticle dose, the ability of nanoparticles to spread within the body, as well as their solubility. Some nanoparticles dissolve easily and their effects on living organisms are the same as the effects of the chemical they are made of. However, other nanoparticles do not degrade or dissolve readily. Instead, they may accumulate in biological systems and persist for a long time, which makes such nanoparticles of particular concern.

APPLICATIONS OF NANOPARTICLES IN THE SOCIETY

There are several areas of science and technology in which nanoscale structures are under active development or already in practical use.

In materials science, nanocomposites with nanoscale dispersed phases and nanocrystalline materials in which the very fine grain size affords quite different mechanical properties to conventional microstructures are already in use. In surface science and surface engineering, nanotopographies offer substantially different properties related to adhesion, tribology, optics and electronic behaviour. Supramolecular chemistry and catalysis have led to novel surface and size dependent chemistry, such as enantioselective catalysis at surfaces. In biological sciences, fundamental understanding of molecular motors and molecular functional entities on the nanometre scale has been responsible for advances in drug design and targeting. Nanoscale functionalised entities and devices are in development for analytical and instrumental applications in biology and

medicine, including tissue engineering and imaging.

The application areas in which these advances in nanoscience are making their biggest impact include electronic, electro-optic and optical devices[6-7]. The transition from semiconductor (conventional and organic) technology to nanoscale devices has anticipated improved properties and resolution, e.g. fluorescence labelling, scanning probe microscopy and confocal microscopy. Data storage devices based on nanostructures provide smaller, faster, and lower consumption systems.

Nanoparticles can contribute to stronger, lighter, cleaner and "smarter" surfaces and systems. They are already being used in the manufacture of scratchproof eyeglasses, crack-resistant paints, anti-graffiti coatings for walls, transparent sunscreens, stain-repellent fabrics, self-cleaning windows and ceramic coatings for solar cells.

Nanomaterials are also being used in biology and medicine in a wide variety of ways. Examples include products for drug delivery and gene therapy, tissue engineering, DNA probes and nanoscale "biochips. In living systems, the nanoparticles may immediately adsorb onto their surface. The ability of nanoparticles to have molecules "sticking" to their surface depends on the surface characteristics of the particles and can be relevant for drug delivery uses. Indeed, it is possible to deliver a drug directly to a specific cell in the body by designing the surface of a nanoparticle so that it adsorbs specifically onto the surface of the target cell. In medicine, greater understanding of the origin of diseases on the nanometre scale is being derived, and drug delivery through functionalised nanostructures may result in improved pharmacokinetic and targeting properties. A wide variety of functional nanoscale materials and functional nanoscale surfaces are in use in consumer products, including cosmetics and sunscreens, fibres and textiles, dyes, fillers, paints, emulsions and colloids.

A wide range of industrial sectors is involved in the development of nanomaterials for a multitude of applications, some of which are already in industrial production. Such cases include carbon nanotubes, the structure of which is one hundred times more resistant and six times lighter than steel, titanium dioxide nanoparticles used in the cosmetics sector, silica nanoparticles for tyres, and cerine as a fuel additive. In particular, nanomaterials may be developed to produce self-cleaning or self-adhesive properties on a surface, increase the toughness of a particular material, improve resistance to friction, improve the quality of textiles, etc. The use of nanomaterials may be observed in the building, automobile, health, cosmetics, chemical, textiles,energy and environment sectors among others.

CONCLUSIONS

The CdS:Mn nanoparticles have been successfully synthesized by a simple precipitation reaction in which mercaptoethanol was used as a capping agent. The particle size measured by both XRD and SEM was found to be in the range 2-4 nm. Reduction in size to the nanoscale changes the characteristics of particles, primarily due to the increased surface to

volume ratio. Nanoparticles exhibit increased diffusivity with decreasing size and therefore show delayed sedimentation in the earth's gravitational field, which translates into potentially increased lifetimes for nanoparticulate impurities at low concentration. Because of the inverse relationship between particle size and surface area, it is imperative that, for various environmental (model) species, (1) dose (or concentration) – effect relationships are established as a function of number of particles rather than mass units and (2) a comparison is made between the effects of the conventional and the nanoparticle form(s) of the substance.

The major steps required assessing the risks for humans and ecosystems are:

- The mechanisms and the rate at which nanoparticles are released from products and processes.
- The actual levels of exposure to nanoparticles, both for humans and the environment.
- The extent to which it is possible to calculate the toxicology of nanoparticles from the knowledge on the same chemicals in larger physical forms.
- The effects that nanoparticles cause at cellular level, and how target organs respond to different doses of nanoparticles.
- The exposure and related health effects of workers involved in the production and processing of nanoparticles.
- The behaviour of nanoparticles in the environment and the environmental species.

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